Thus:

$$M = nt$$

$$= \frac{R\rho L}{v_2} \quad \text{[where } L \text{ is the length of the large vessel's track through the area]}$$

$$= \frac{\rho L}{\pi}\left[2(l_1 + \lambda l_2) + b_2\pi + \lambda b_1\pi + 2b_1(\sin T - \lambda T)\right]$$

[where $\lambda = (v_1/v_2)$ and $T = \cos^{-1}\lambda$]

Note that when the yachts are small compared to the large vessel, the term $2b_1$ $(\sin T - \lambda T)$ is very small and may be neglected. The expression then becomes:

$$M = L\rho\left[\frac{2(l_1 + \lambda l_2)}{\pi} + (b_2 + \lambda b_1)\right]$$

Inertial Navigation

Claud Powell

THE following letter to *Nature*, dated 24 April 1873, might make an appropriate sequel to 'The history of inertial navigation' by W. Wrigley in the January issue of the *Journal*. As well as containing some interesting speculation about animal navigation, which we seem no nearer resolving a century later, the letter includes an introduction to the idea of inertial navigation that it would be difficult to improve upon even today.

INSTINCT: A MECHANICAL ANALOGY

MR. DARWIN, in his article on 'The Origin of certain Instincts,' in *Nature* of April 3, appears inclined to think that what we may call the instinct of direction in animals is of the same kind as the faculty by which men find their way: and he instances the power of the natives of Siberia to find their way over hummocky ice. He afterwards, however, raises without discussing the question 'whether animals may not possess the faculty of keeping a dead reckoning of their course in a much more perfect degree than man, or whether this faculty may not come into play on the commencement of a journey when an animal is shut up in a basket.' I wish to point out that this peculiar power of animals is one that cannot be explained as a higher degree of any power that man possesses. What man can do is to find the third side of a triangle after travelling the other two sides *with his eyes open*. Animals can do the same after travelling the two sides *with their eyes shut*. The former power of man here spoken of depends on the careful use of his powers of observation. This does not appear to be the case with animals. Among the many instances of animals finding their way home after being conveyed away without any opportunity of seeing their way or taking their bearings, there must in all probability be many in which the animal slept on the journey: and if so, the mental or organic process whereby it was able to know its way back must have gone on during sleep. There is nothing in man's

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mind similar to such a process as this. It can be made conceivable only by a mechanical analogy, if at all.

If a ball is freely suspended from the roof of a railway carriage, it will receive a shock sufficient to move it, when the carriage is set in motion: and the magnitude and direction of the shock thus given to the ball will depend on the magnitude and direction of the force with which the carriage begins to move. While the carriage is in uniform motion the ball will be relatively at rest; and every change in the velocity of the motion of the carriage, and of its direction, will give a shock of corresponding magnitude and direction to the ball. Now, it is conceivably quite possible, though such delicacy of mechanism is not to be hoped for, that a machine should be constructed, in connection with a chronometer, for registering the magnitude and direction of all these shocks, with the time at which each occurred; and from these data—the direction of the shock indicating the direction of the motion of the carriage, the magnitude of the shock indicating its velocity, and the interval of time between two shocks indicating the time during which the carriage has run without change of velocity or direction—from these data the position of the carriage, expressed in terms of distance and direction from the place from which it had set out, might be calculated at any moment. The automatic register of the journey may be conceived as exactly resembling the records of the velocity and direction of the wind produced by one of Robinson's or Beck's self-registering anemometers, where one pencil-mark indicates the direction of the wind, at any past hour, and another its velocity.

Further, it is possible to conceive the apparatus as so integrating its results as to enable the distance and direction of the point where the journey began to the point it has reached, that they can be read off, without any calculation being needed:—a hand on a dial pointing to the direction expressed in degrees of the circle, and the distance being shown in figures expressing miles and decimals of a mile.

Now, I suppose such an integrating process as this (though of course not by any similar mechanism) to be effected in the brain of an animal unconsciously, and that the animal has the power of reading off the result—that is to say, bringing it into consciousness when wanted.

Joseph John Murphy

Old Forge, Dunmurry, Co. Antrim, April 11

The Role of Lighting in Aids to Marine Navigation

P. Clissold

L. G. REYNOLD's interesting article (*Journal* **30**, 108) gives rise to a question. Why, on the new charts is the light range given as the luminous or nominal range, instead of, as formerly, the geographical range (for a height of eye of 15 ft)? This, from the point of view of the practical navigator, seems a retrograde step for we can no longer see from a glance at the chart the approximate